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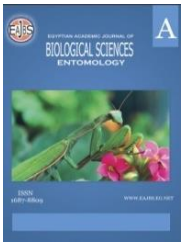

Changes in Histological Characters and Biochemical Attributes in the Tomato Hybrids Infested with *Tetranychus urticae* Koch (Acari: Tetranychidae)

Ayat M.A. El-Sayed; Rahil, A.A.R; Mahmoud, M.F.R. and Sherin H.M. Safar
Plant Protection Departement, Faculty of Agriculture, Fayoum University, Fayoum 63514, Egypt.
*__E-mail:__ ama42@fayoum.edu.eg, AshrafRahil1960@gmail.com, MaherFoad70@gmail.com, shm02@fayoum.edu.eg,

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ABSTRACT

Our study was conducted to determine how red spider mite infection affected tomato leaves' histological characters and biochemical attributes. *Tetranychus urticae* infection impacts four tomato hybrids, 09, Supper-gekal, Super strain B, and Blatenium on particular histological traits and biochemical elements. Thirty leaf samples of each infested and uninfested plant were collected, transported to the lab, and prepared for histological and biochemical analysis. As a result of infestation, the thickness µm of epidermis and parenchyma cells of tomato leaves in all examined hybrids was influenced, it decreased for upper and lower epidermis cells and conversely, it increased in the case of parenchyma cells compared with uninfested tomato leaves as a control. In all tested hybrids, mite infestation lowered photosynthetic pigments such as chlorophyll a, b, and total carotenoids in addition to the indicators of photosynthetic activity. The percentage loss of photosynthetic pigments of the 09 hybrid was affected more than the other three hybrids recording 37.47, 23.99, and 34.27% of chlorophyll a, b, and total carotenoids. Some organic substances were evaluated in 09 hybrids including lipids, carbohydrates, proteins, flavonoids, phenols, and alkaloids plus, nutrients such as total nitrogen, potassium, and phosphorus. Results revealed that mite infestation affected all tested biochemical components. Lipids, proteins, phenols, and alkaloids were generally higher in infested leaves (1.69, 18.84, 1.211, and 0.94 g/100g), respectively than in uninfested leaves (1.53, 18.66, 0.963, and 0.68 g/100g). Flavonoids and carbohydrates were significantly reduced in infested leaves, measuring 19.38 and 0.042 (g/100 g), respectively as opposed to 21.78 and 0.084 (g/100g) in uninfested leaves.

INTRODUCTION

The two-spotted spider mite (*Tetranychus urticae*, Order: Trombidiformes, Family: Tetranychidae) has emerged as a highly destructive pest of Solanaceae plants in Africa, causing estimated crop reductions of up to 90% in South East Africa (Sibanda, *et al*., 2000)**.** Tomato (*Solanum lycopersicum* L., Order: Solanales, Family: Solanaceae) is one of the most commonly cultivated vegetables globally. It possesses significant value in the

fresh markets and serves as a crucial ingredient in the production of diverse industrial products (FAO, 2020). Plant reactions to herbivores are complicated. The genes that are activated in response to herbivore attacks are strongly associated with the specific way in which the herbivore feeds and the extent of tissue damage caused at the feeding site. Attacks by herbivores are closely tied to how they feed and how much tissue damage is present where they are grazing. They are toxic and lose fitness as a result of the protective proteins that plants produce. *Tetranychus urticae* primarily affects the mature and old leaves of tomato plants by the process of sap-sucking, causing damage to the chlorophyll-producing structures and reducing photosynthesis by depleting the cell sap. (Walling, 2000, Wu and Baldwin, 2010**,** Biswas, *et al*., 2004) and (Fürstenberg-Hägg, Zagrobelny, and Bak, 2013)**.** *Tetranychus urticae* is a generalist-sucking pest that consumes leaf mesophyll cells located on the leaves' underside, where it is shielded from UV light. It has been evaluated that each individual causes damage to approximately 18-22 plant cells per minute. This results in the appearance of white spots on leaves, early leaf shedding, and substantial losses in tomato plants (Ohtsuka and Osakabe, 2009 and Zanin *et al.*, 2018). Direct mechanisms encompass morphological structures, for instance, hairs and trichomes, as well as the synthesis of chemicals including acyl-sugars, waxes, latex, and callose. These mechanisms serve as the initial barrier to deter herbivore attacks (Santamaria, *et al.*, 2013). The vulnerability of tomato hybrids to *T. urticae* infection is crucial for identifying the most resistant varieties, hence reducing the need for pesticides. The population levels of herbivores can be influenced by the morphological, histological, and chemical leaf properties, which typically differ across different plant varieties (El-Saiedy, *et al*., 2011) and (Afify, *et al*., 2009)**.** Plants have many morphological, biochemical, and molecular methods to resist adverse impacts of herbivore attack (War, *et al.*, 2012). The vulnerability of five tomato hybrids (Supper-gekal, F1Gs-12, Marwa, Elbasha 1077, and Salymia 65010) to infestation by *T. urticae* is influenced by the histological features of plant leaves, including the average thickness of the upper and lower epidermis, and the chemical composition of the leaves. Tomato leaves have a direct relationship between the levels of mite infestation and total carbohydrates, but there is a negative correlation between alkaloids and total phenolic, flavonoid, and carotenoid components (Ali, *et al.*, 2015). The thickness µm of the epidermis, parenchyma cells, and various components in sponge and palisade parenchyma cells, such as the cellular wall, intercellular space, chloroplasts, and many starch grains, were influenced by the presence of enhanced resistance compounds (potassium silicates, potassium humates, methyl jasmonate, and salicylic acid) utilized in resistance improvement against *T. urticae* in tomato hybrids; Supper-gekal and Salymia examined them using transmission electron micrograph (Ahmed, 2018). It is crucial to choose tomato hybrids that are resistant to *T. urticae* infestations in order to reduce the need for additional insecticides. Herbivore populations can be influenced by the morphological, histological, and chemical leaf characteristics, which can vary between different plant varieties. (El-Saiedy, *et al*., 2011) and (Afifi, El-Bishlawy, and Mahmoud, 2013)**.** Spider mite fertility and growth affect many important variables, including repellents, defence compounds, and volatile molecules in host plants (Hoy, 2016)**.** *Tetranychus urticae* causes mechanical damage made up of empty cells, which causes the damaged organ to seem dull and may subsequently turn blackish as more necrotic cells proliferate. In addition, the act of feeding has an impact on the composition of cells, leading to decreased levels of nitrogen, phosphate, and protein. It also affects cell physiology, disturbing the process of photosynthesis and injecting phytotoxic substances that reduce crop yields (Johnson and Lyon, 1991). The phenolic compounds play different roles as anti-feedants, digestibility reducers, or direct poisons. They are significant parts of secondary metabolites (Johnson and Felton, 2001)**.** Spider mites extract nutrients from the

leaf tissue by inserting their stylets and extracting the cellular contents; this leads to the degradation of leaf chlorophyll a and b and subsequent decline in the net photosynthetic rate, which causes leaf bronzing and a decrease in the general health of plants, perhaps resulting in plant mortality (Park and Lee, 2002). Arthropods are prevented from feeding and ovipositing by allelochemicals (alkaloids, flavonoids, terpenes, and phenols) that are produced by many plants and retained in the cell walls of the leaves (Smith, 2005)**.** *T. urticae* population density was adversely linked with the chlorophyll content of rose and okra plants (Geroh, Gulati, and Tehri, 2014)**.** It has previously been documented that *T. urticae* feeding results in aesthetic damage, morphological and biochemical changes in makeup of leaves and fruit (Farouk and Osman, 2012)**.** Multiple studies on the interactions between tomato plants and spider mites have emphasized the significance of inherent defensive mechanisms, such as the chemical composition and abundance of glandular trichomes, in protecting wild tomato relatives against spider mites (Glas *et al.*, 2012). According to (Mithöfer and Boland, 2012) phytochemicals perform important defence roles for plants against herbivorous insects by either decreasing the plant's nutritional value or stimulating the synthesis of defence mechanisms such as feeding deterrents. Despite the variety of ways that plants and herbivores interact, jasmonic acid (JA) has been found to be a key regulator of plants' responses to herbivory in terms of defence (Campos, Kang, and Howe, 2014). Prosthetic groups, which gives it a significant role in the metabolism of matter and energy (Cao, van Loosdrecht, and Daigger, 2017)

The objective of this study was to estimate the effects of *T. urticae* infestation on histological characteristics and the concentrations of photosynthetic pigments (chlorophyll a, chlorophyll b and total carotenoids) in four tomato hybrids to assess the level of their tolerance. Also, the changes in some biochemical attributes of the 09 hybrids were determined.

MATERIALS AND METHODS

A-Effect of Infestation with *Tetranychus urticae* on the Histological Features of Tomato Hybrids:

Four tomato hybrids, 09, Supper-gekal, Super strain B, and Blatenium were planted; forty-five days later, the leaves were infested by *T. urticae*. Collected specimens were taken from the fourth leaf at the growing point and transferred to the Faculty of Agriculture Research, Cairo University, for observation of leaf anatomy. Using microtechnique procedures, Nassar, and El-Sahhar 1998, three samples of each tomato hybrid were sacrificed and fixed for at least 48 hrs. in FAA solution (50 cm^3 of 95% (v/v) ethanol + 10 cm^3 of formaldehyde + 5 cm^3 of glacial acetic acid + 35 cm^3 of distilled water). Subsequently, the samples underwent a washing process in 50% ethyl alcohol and were dehydrated in a series of n-butyl alcohols before being embedded in paraffin wax (mp 56–58 °C). Transverse sections were cut on a rotary microtome to a thickness of 20 microns. Then, they were stained with either crystal violet or erythrosin before being mounted in Canada balsam. The slides were examined using microscopic analysis and photomicrography.

B- Effect of Infestation with *T. urticae* on Photosynthetic Pigments of Four Tomato Hybrids:

Chemical analysis of leaf samples was conducted using collected samples of thirty infested (10 individuals each) and thirty uninfested definite leaves from the same age and position. Leaves of tomato hybrids (09, Supper-gekal, Super strain B, and Blatenium) were transferred to the Faculty of Agriculture Research, Cairo University, for chemical analysis. The Photosynthetic pigments as total carotenoids and chlorophyll a & b were estimated

colorimetrically considering (Goodwin, 1965) using three replicates for each tomato hybrid (infested and uninfested).

B- Effect of Infestation with *T. urticae* on Some Biochemical Attributes of 09 Tomato Hybrid:

The same previous method used for sampling tomato hybrid leaves to estimate photosynthetic pigments was repeated with 09 tomato hybrid leaves. Samples also were transferred to the Faculty of Agriculture Research, Cairo University, for chemical analysis. Some specific chemical components of 09 tomato hybrid leaves were determined using three replicates for each infested and uninfested leaf as follows:

1-Major Organic Compounds (Total lipids, Total carbohydrates, Total protein):

1-1- Total lipids were determined according to the method described in (Bligh and Dyer 1959)**.**

1-2-Total carbohydrates were extracted from the plant leaves and prepared for assay as per the specified method (Crompton and Birt 1967)**.**

1-3-Total protein was calorically evaluated by ninhydrin reagent regarding (Lee and Takahashi 1966)**.**

2-Minor organic compounds (Total phenol, Total flavonoids, Alkaloids):

2.1. Total phenol content was determined by Folin- Ciocateu method as modified by (Singleton and Rossi 1965)**.**

2.2. Total flavonoid content was determined by the Folin-Ciocalteu method according to (Martín-García et al. 2019)

2.3. Alkaloids were determined using a titrimetric method based on (Sabri, el-Masry, and Khafagy 1973)

3-Nutrients (Metcalfe and Prichard 1987):

3.1. Total nitrogen (N)

3.2. Potassium (K)

3.3. Phosphorus (P)

C- Statistical Analysis:

The effect of infestation on the chemical components of tomato hybrids was analysed using one-way analysis ANOVA. A two-sample t-test was utilized to test the difference between different photosynthetic pigments of four tested tomato hybrids concerning the infestation resulting from *T. urticae* in addition to test the difference between some chemical attributes of infested and uninfested leaves of 09 hybrid. A significance assessment was conducted using 0.05-level probabilities.

RESULTS

A. Effect of Infestation with *Tetranychus urticae* on the Histological Features of Tomato Hybrids:

Data from photomicrograph microscope examination of the cross-section of different four tomato hybrid leaves infested by *Tetranychus urticae* illustrated some histological modifications while the uninfested one illustrated the regular one (Table 1 and Fig. 1). Epidermis of infested four tomato hybrid leaves as the mean thickness of the upper epidermis and lower epidermis was decreased due to mite infestation. The lower epidermis was recorded at 11.58, 13.53, 5.26, and 7.59 µm compared with 23.94, 20.23, 7.65, and 12.74 µm in uninfested 09, Supper-gekal, Super-strain B, and Blatenium hybrids, respectively, the rate of change was increased recording 12.36, 6.7, 2.39 and 5.15, respectively. While the mean thickness of the upper epidermis varied to record 16.28, 25.35, 19.67, and 15.2 µm compared with 10.79, 12.59, 15.17, and 13.94 µm in the infested one, the rate of thickness change was increased recording 5.49, 12.76, 4.5 and

1.26, for the previous hybrids. Supper-gekal was the hybrid with the greatest levels of lower epidermis damage, whereas Blatenium had the lowest levels. While Super-strain B had the least effect on the upper epidermis and hybrid 09 had the highest.

The mean thickness of the Mesophyll tissues was determined in a transverse section of tomato leaves as the values of palisade and spongy parenchyma thickness. The effect of *T. urticae* infestation on palisade parenchyma varied among four tomato hybrids; the mean thickness of palisade parenchyma-infested leaves was increased for all hybrids when compared with an uninfested one.

The average thickness of palisade parenchyma was recorded at 107.37, 114.07, 66.79, and 84.29 µm in 09, Supper gekal, Super-strain B, and Blatenium, respectively, compared with infested hybrids, which were recorded 127.55, 129.70, 81.12, and 92.49 µm while the thickness change rate was decreased recording -20.18,-15.63, -14.33 and -8.2 on the same previous hybrids, respectively. In comparison to other tomato hybrids, hybrid 09 shows the greatest decrease in Palisade parenchyma thickness. Additionally, the leaves of tomato hybrids varied in the average thickness of the spongy parenchyma. Infested hybrids were recorded 162.80, 187.20, 87.64, and 82.39 µm on the previous hybrids, respectively, compared with 155.38, 103.44, 83.35, and 70.89 µm in the uninfested ones, and the thickness change rate was decreased recording -7.42, -83.76, -4.29 and -11.5, respectively. The results showed that the upper epidermis and lower epidermis of four tomato hybrids detected a greater change in thickness than the mesophyll tissues (palisade parenchyma and spongy parenchyma), which experienced a smaller change in thickness.

Table 1: Effect of *Tetranychus urticae* infestation on some measurements of epidermis and paranchyma cells in transverse sections of tested tomato hybrids leaves.

Tomato hybrids	Mean thickness µm ± SE								
	Hybrids	Upper	TCR	Palisade	TCR	Spongy	TCR	Lower	TCR
09	Infested	10.79±0.89	5.49	127.55±2.27	-20.2	162.80±3.80	-7.42	11.58±0.61	12.36
	Uninfested	16.28±0.99		107.37±1.34		155.38±2.73		23.94±0.88	
Supper-gekal	Infested	12.59±0.79	12.76	129.70±2.14	-15.6	187.20±3.16	-83.8	13.53±0.39	6.7
	Uninfested	25.35±7.79		114.07±3.46		103.44±4.32		20.23±0.73	
Super strain B	Infested	15.17±0.43	4.5	81.12±1.77	-14.3	87.64±3.76	-4.29	5.26±0.26	2.39
	Uninfested	19.67±1.6		66.79±2.58		83.35±1.11		7.65±0.62	
Blatenium	Infested	13.94±0.76	1.26	92.49±1.56	-8.2	82.39±3.49	-11.5	7.59±0.69	5.15
	Uninfested	15.2±0.66		84.29±1.91		70.89±2.13		12.74±0.79	

*Thickness Change Rate (TCR)= Thickness of uninfested leaves - Thickness of infested leaves.

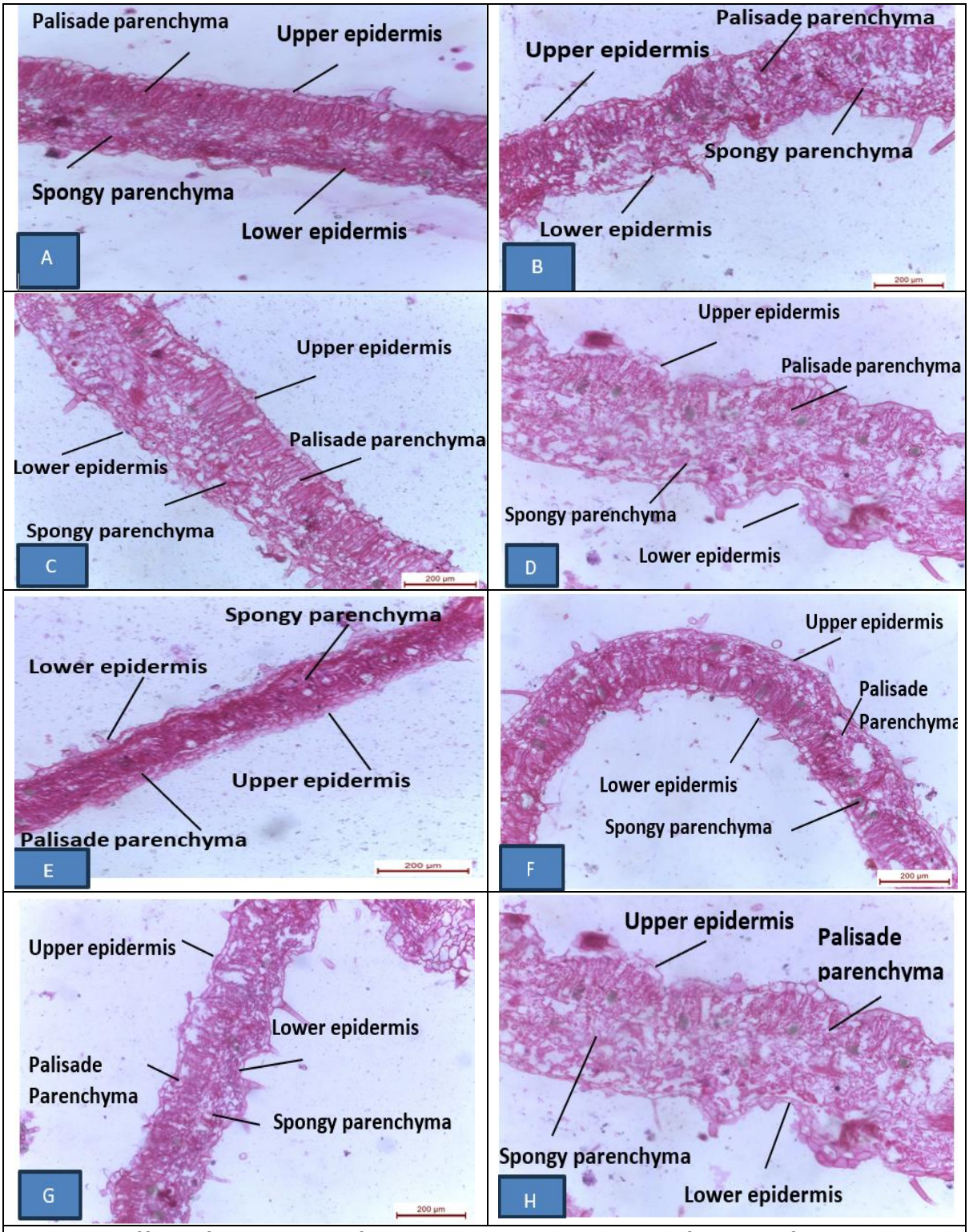

Fig. 1. Effect of *T. urticae* infestation on some histological features of tomato hybrid leaves. A: uninfested 09, B: infested 09, C: uninfested Supper-gekal, D: infested Supper-gekal, E: uninfested Super strain B, F: infested Super strain B, G: uninfested Blatenium, H: infested Blatenium.

B. Effect of Infestation with *T. urticae* on Photosynthetic Pigments of Tomato Hybrids:

For each tomato hybrid, the photosynthetic pigments were determined independently. Significant changes were observed during the comparative analysis done on the photosynthetic pigments of mite uninfested and infested leaves of tomato hybrids. They were represented in chlorophyll a, b, and total carotenoids. Tomato leaves afflicted with mites exhibited a notable decrease in chlorophyll levels, reflecting a loss in photosynthetic efficiency.

As shown in Table 2 and Figure 2, Photosynthetic pigments were found to be greater in uninfested Supper-gekal tomato hybrid leaves compared with the other three hybrids. In all infested hybrid leaves compared with uninfested ones, all pigments were significantly decreased (t-test ≤ 0.05) except in the case of the Super-strain B hybrid. Results revealed that the photosynthetic pigments were affected due to the mite infestation. For 09 hybrid, results showed that the mite infestation reduced chlorophyll a, b, and total carotenoids, which decreased the photosynthesis in tomato leaves. They are recorded at 4.84, 3.39, and 592.62 (µg/g) in infested leaves, respectively, as opposed to 7.74, 4.46, and 901.65 (µg/g) in uninfested ones. There were noticeable changes due to infestation. While chlorophyll a and carotenoid contents were significantly decreased according to the mite infestation recording 11.48 and 1317.52 µg/g in Supper gekal hybrid infested leaves compared with 12.36 and 1368.78 µg/g in the uninfested ones, respectively. The chlorophyll b was slightly increased according to infestation, it was recorded at 6.48 µg/g in infested leaves compared with 6.20 µg/g in the uninfested ones (Table 2 and Fig.2).

Super strain B hybrid showed a significant reduction in total carotenoids. They were recorded at 795.61 (µg/g) in infested leaves compared with 1013.22 (µg/g) in the uninfested ones, while, chlorophyll a and chlorophyll b contents were even with decreasing or increasing values according to the mite infestation are insignificant values, recorded 7.78 and 4.27 µg/g in infested leaves compared with 7.55 and 4.61 µg/g in the uninfested ones, respectively. For the Blatenium hybrid, mite infestation significantly changed photosynthetic pigment values.

The chlorophyll a and chlorophyll b contents were significantly decreased according to the mite infestation, which recorded 8.93 and 4.93 µg/g in infested leaves compared with 9.28 and 5.17 µg/g in the uninfested ones, respectively. While the carotenoids were increased according to the mite infestation, 991.55 (µg/g) were recorded in infested leaves compared with 990.31 (µg/g) in the uninfested ones.

The differences between infested and uninfested leaves regardless of hybrids were significant in Chlorophyll a and total carotenoids and insignificant in chlorophyll b.

The percentage loss of photosynthetic pigments of hybrid 09 was affected more than the other three hybrids recording 37.47, 23.99, and 34.27% of chlorophyll a, b, and total carotenoids, respectively.

Table 2: Effect of infestation with *T. urticae* on photosynthetic pigments of tomato hybrid leaves.

Tomato hybrids	Infestation	photosynthetic pigments		
		Chlorophyll A (µg/g) "FW."	Chlorophyll B (µg/g) "FW."	T. Carotenoids (µg/g) "FW."
09	Uninfested	7.74	4.46	901.65
	Infested	4.84	3.39	592.62
	Paired T- test	0.000	0.002	0.000
	Loss (µg/g)	2.9	1.07	309.03
	loss%	37.47	23.99	34.27
Supper-gekal	Uninfested	12.36	6.20	1368.78
	Infested	11.48	6.48	1317.52
	Paired T- test	0.006	0.025	0.000
	Loss (µg/g)	0.88	---	51.26
	loss%	7.11	---	3.74
Super-strain B	Uninfested	7.55	4.61	1013.22
	Infested	7.78	4.27	795.61
	Paired T- test	0.582	0.448	0.000
	Loss (µg/g)	---	0.34	217.61
	loss%	---	7.38	21.48
Blatenium	Uninfested	9.28	5.17	990.31
	Infested	8.93	4.93	991.55
	Paired T- test	0.021	0.031	0.001
	Loss (µg/g)	0.35	0.24	---
	loss%	3.77	4.64	---
Sig. regardless of hybrids	Paired T-test	0.021	0.063	0.003

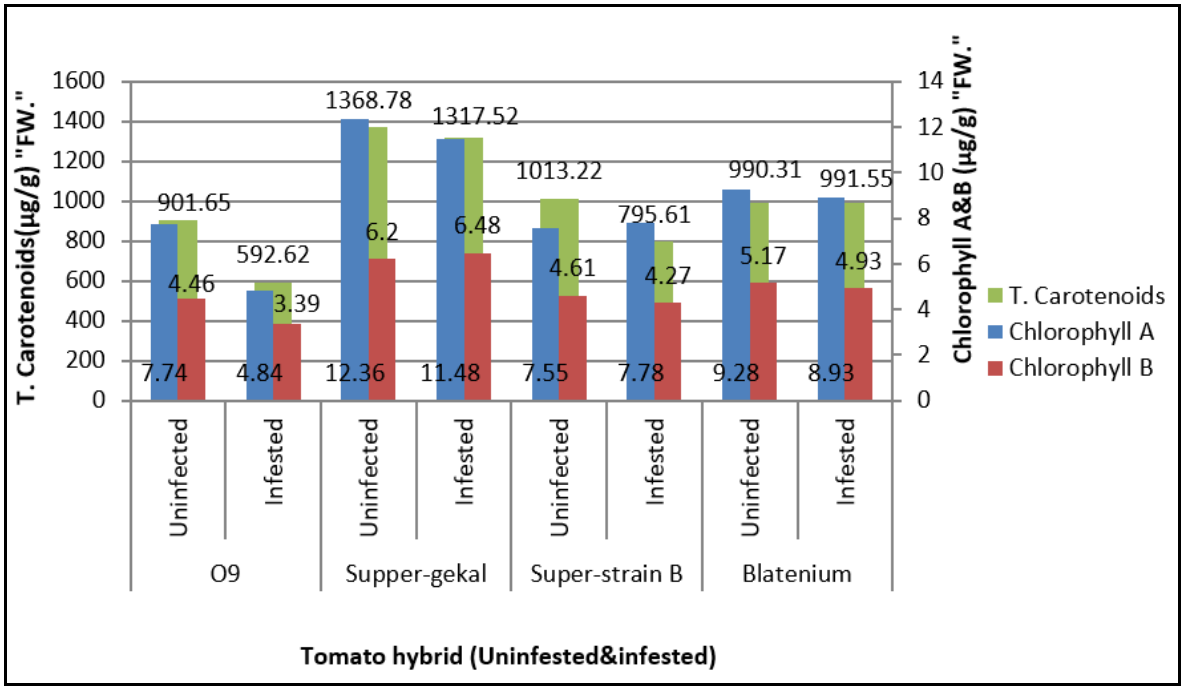

Fig.2: Effect of *T. urticae* infestation on photosynthetic pigments of tomato hybrids leaves.

C-Influence of *T. urticae* Infestation on the Biochemical Attributes of 09 Tomato Hybrid:

Since the 09 hybrid was one of the hybrids most affected by mite infestation, both in its effect on the damage of the upper epidermis layer as well as the percentage of

pigment loss, it was chosen to conduct an analysis of some chemical components to determine the extent to which they are affected by the infestation.

Table 3, indicates that the presence of mites had an impact on the number of organic constituents (lipids, proteins, phenols, and alkaloids) that were generally higher in infested leaves (1.69, 18.84, 1.211, and 0.94 g/100g), respectively, than in uninfested leaves (1.53, 18.66, 0.963, and 0.68 g/100g). Flavonoids and carbohydrates were significantly reduced in infected leaves, measuring 19.38 and 0.042 (g/100 g), respectively, as opposed to 21.78 and 0.084 (g/100g) in uninfected leaves. Finally, from the three nutrients evaluated, nitrogen content was insignificantly increased (3.02 g/100g) in infested leaves compared with (2.99 g/100g) in uninfested ones, respectively. While phosphorus and potassium contents were decreased by 0.06% and 6.774% in infested leaves and 0.10% and 11.188% in uninfested ones.

Table 3: Infestation influence of *T. urticae* on some biochemical attributes of 09 tomato hybrid leaves.

Biochemical components		Uninfested	Infested	Paired T-test
Major organic compounds	T. Lipids (g/100g) "D.W. "	1.53	1.69	0.003
	T. Carbohydrates(g/100g) "D.W."	21.78	19.38	0.000
	T. Proteins (g/100g) "D.W. "	18.66	18.84	0.029
Minor organic compounds	T. Flavonoids (g/100g) "D.W. "	0.084	0.042	0.006
	T. Phenols (g/100g) "D.W. "	0.963	1.211	0.000
	T. Alkaloids (g/100g) "D.W. "	0.68	0.94	0.013
Nutrients	T. Nitrogen (g/100g) "D.W. "	2.99	3.02	0.744
	Potassium (%) "D.W. "	11.188	6.774	0.024
	Phosphorus (%) "D.W. "	0.10	0.06	0.369

Data concluded that all biochemical attributes of the 09-tomato hybrid were significantly affected by mite infestation except the nitrogen and phosphorus contents, which were insignificantly affected.

DISCUSSION

Four tomato varieties were selected and evaluated for their response to two-spotted spider mite infestation. Spider mites belonging to the *Tetranychus* genus (Tetranychidae) are phytophagous acari that use tube-feeding mechanisms to pierce plant parenchymatic cells and extract their contents (Bensoussan, *et al*. 2016).

A similar observation of the effect of mite infestation on the histology of plant leaves was reported by (Rasha, Elhalawany, *et al* 2020), They studied the changes in the anatomical composition of three types of squash caused by the infestation of *T. urticae* using light microscopy. The results indicated that infestation with *T. urticae* induced significant changes in the anatomical structure of the leaves of three squash varieties. These changes led to a decrease in the mean thickness of the lower epidermis of Eskandarani, Hytech, and Milet by -30.13%, -28.59%, and -30.35%, respectively. However, the mean thickness of palisade tissues in three varieties increased by +14.34, +24.72, and +33.61, respectively. Also, the mean thickness of spongy tissues was increased by +29.81, +153.45, and +88.88 in Eskandarani, Hytech, and Milet, respectively. Eventually, a reduction in the mean thickness of the upper epidermis was observed in three varieties by -16.11, -23.04, and -26.42. The increase in the upper and lower epidermis may result in resistance against mite infestation.

Different observations were recorded by (Jeppson, Keifer, and Baker, 1975) and **(**Park and Lee, 2002**)** showing that the decrease in thickness of mesophyll tissue may be

due to *T. urticae* feeding through spongy and palisade parenchyma and consuming mesophyll cell contents. The increase in the upper and lower epidermis may result in resistance against mite infestation. (Geroh, *et al*., 2014) reported a similar finding concerning the impact of mite infestation on photosynthetic pigments. They found that the amount of chlorophyll in rose and okra plants decreased as the population density of *T. urticae* increased. (Tehri *et al*., 2014) demonstrated the harmful effects of the two-spotted spider mite *T. urticae* on cucumber plants, namely *Cucumis sativus*. A strong inverse association was observed between photosynthetic pigments and mite populations. The levels of carotenoids, total chlorophyll, chlorophyll-a, and chlorophyll-b dropped to a maximum of 47.27%, 40%, 43.63%, and 45.45%, respectively, at the highest infestation density compared to the control. Also, (Johnson and Felton, 2001) stated that phenolic compounds are important components of secondary metabolites that function variously as anti-feedants, digestibility reducers, or direct toxins.

(Park and Lee, 2002) found that spider mites feed by inserting their stylets into leaf tissue and extracting cell contents. This leads to a decrease in leaf chlorophyll and a consequent decrease in net photosynthetic rate, resulting in leaf discoloration, commonly known as bronzing. This decline in plant health can ultimately lead to plant death. (Sun, 2021) also supports this, stating that chlorophyll content is a crucial biochemical indicator of crop development. Sun further demonstrates that the amount of chlorophyll in jujube trees varies depending on the severity of leaf mite infestation. Furthermore, the presence of scale insects resulted in a reduction in both chlorophyll and carotenoid levels, as well as a decrease in the value of three indicators that measure photosynthetic activity (Golan, 2015).

(Abdallah, *et al*., 2018) mentioned that results of chemical analysis of leaf components after *Tetranychus urticae* infestation indicated positive relationships in case of total phenol (r = 1) for the three cultivars (Mabroka, Brencesa, and Eskandarani). While the amount of protein, chlorophyll and carbohydrates were significantly decreased. Their (r) values were (-1) in the three squash cultivars.

According to (Ali, *et al*., 2015), the vulnerability of five tomato hybrids (Salymia 65010, Elbasha 1077, Marwa, F1Gs-12, and Supper-gekal) to *T. urticae* infection could be influenced by the chemical composition of the plant leaves. There is a direct correlation between the levels of mite infestation and the amount of total carbohydrates in tomato leaves. Conversely, there is an inverse correlation with total carotenes, total flavonoids, total phenolic compounds, and alkaloids. In 2021, Vibija conducted a study on the bamboo spider mite, specifically the species *Schizotetranychus schizopus* (Zacher, 1913), which infests the Indian Thorny Bamboo known as *Bambusa bambos* (L.) Voss. The data shows a substantial decrease in the fluorescence of chlorophyll (a 30.10% reduction in the Fv/Fm ratio), indicating a deterioration in the efficiency of photosynthesis. Mite-infested leaves showed a substantial decrease in both total protein (21.02%) and total carbohydrate (58.87%) levels. Furthermore, it was discovered that mite infestation significantly increases the synthesis of stress-inducing substances, including proline (69.05%) and total Phenol (22.86%). An elevation in the absorption of micro and macronutrients such as zinc (19.62%), copper (48.76%), calcium (36.66%), and potassium (18.87%) was further noted in leaves affected by mite infestation.

CONCLUSION

In conclusion, according to our present study findings, *Tetranychus urticae* infestation had an effect on some histological characteristics and some biochemical attributes of the leaves of the selected tomato hybrids when compared with the control group. The impact of *T. urticae* infestation on palisade parenchyma and spongy leaves varied among four tomato hybrids; the mean thickness of palisade parenchyma and spongy

infested leaves increased for all hybrids when compared with uninfested ones. Lower epidermis and upper epidermis-infested leaves were decreased for all hybrids.

Mite infestation showed a significant reduction in the levels of photosynthetic pigments (total carotenoids, chlorophyll a, and b) in all tested hybrids except Super strain B which was insignificantly affected. The percentage loss of photosynthetic pigments of hybrid 09 was affected more than the other three hybrids recording 37.47, 23.99, and 34.27% of chlorophyll a, b, and total carotenoids, respectively.

All biochemical attributes of the 09-tomato hybrid were significantly affected by mite infestation except the nitrogen and phosphorus contents.

Declarations:

Ethical Approval: Ethical Approval is not applicable.

Competing interests: The authors declare no conflict of interest.

Contributions:I hereby verify that all authors mentioned on the title page have made substantial contributions to the conception and design of the study, have thoroughly reviewed the manuscript, confirm the accuracy and authenticity of the data and its interpretation, and consent to its submission. Ayat, A.M. El-Sayed conducted material preparation, data collecting, and statistical analysis. Rahil, A.A.R., Mahmoud, M.F.R., and Sherin, H.M. Safar evaluated and approved the final article.

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ARABIC SUMMARY

التغيرات في الصفات النسيجية والصفات البيوكيميائية في بعض هجن الطماطم المصابة ب *Tetranychus urticae* Koch (Acari: Tetranychidae)

ايات محمود السيد وأشرف عبد الحفيظ رضوان رحيل، ماهر فؤاد رمضان محمود وشيرين حسن صفر
كلية الزراعة – قسم وقاية النبات – جامعة الفيوم – مصر

تعد الطماطم واحدة من أكثر الخضروات إنتاجًا في العالم ويرجع ذلك لأهميتها الاقتصادية وقيمتها الغذائية العالية وتستخدم كعنصر مهم في صناعة المنتجات المختلفة لتعدد أصنافها واستخداماتها وتصاب هذه النباتات بمختلف اصنافها بأكاروس العنكبوت الأحمر والذي يسبب خسائر اقتصادية كبيرة لذلك تمت دراسة تأثير اكاروس العنكبوت الاحمر على الخصائص الهستولوجيه لأوراق الطماطم حيث اظهرت البيانات المأخوذة من الفحص المجهري للمقطع العرضي للأوراق السليمة والمصابة لأربع اصناف من الطماطم هى , Super-strain B , Supper-gekal , 09 Blatenium انه حدث تغير في سمك طبقات الورقة مثل البارانشيما ووجد إن الصنف الأكثر تأثرا بالاصابة هو(09) مقارنة مع الأصناف الأخرى. بينما اختلف متوسط سمك النسيج الإسفنجي بين الأصناف الأربعة.

كما تم دراسة تأثير اكاروس العنكبوت الاحمر على أصباغ التمثيل الضوئي لأصناف الطماطم الاربعة حيث أوضحت النتائج أن التمثيل الضوئي في أوراق الطماطم قد تأثر بسبب الإصابة حيث قلت جميع أصباغ التمثيل الضوئي مثل الكلوروفيل أ ، ب وإجمالي الكاروتينات في الصنف 09 بينما في الاصناف الثلاثة الاخري قلت جميع الاصباغ ما عدا في حالة الصنف Super-strain B ، زاد محتوى الكلوروفيل أ ، وفي الصنف Supper-gekal زاد الكلوروفيل ب وأخيراً في الصنف Blatenium زاد محتوى الكاروتينات الكلي.وبالنسبة للصنف 09 فقد تمت دراسة تأثير اكاروس العنكبوت الاحمر على بعض المحتويات الكيماويه الاخري له مثل بعض المركبات العضوية وبعض المغذيات وقد اوضحت النتائج انه زادت بعض المركبات العضوية (الدهون والبروتينات والفينولات والقلويدات) وانخفض محتوى الكربوهيدرات والفلافونويدات وزاد النيتروجين الكلي زيادة غير معنوية اما البوتاسيوم فقد انخفض محتوي الاوراق منه.